



Integrated Petroleum Technologies, Inc.

01/10/17

Mr. Pat O'Brien
East Cherry Creek Valley Water and Sanitation District
6201 South Gun Club Road
Aurora, Colorado 80016

RE: 2016 EPA Falloff Test Analysis
EPA UIC Permit CO12143-08425
ECCV DI-1 Injection Well
Section 1 T1S R66W
Adams County, Colorado

Dear Mr. O'Brien:

The EPA pressure falloff test analysis for the 2016 falloff test is attached for the ECCV DI-1 Injection well in Adams County, Colorado.

IPT appreciates the opportunity to work with you and East Cherry Creek Valley Water and Sanitation District on this analysis. Please do not hesitate to call if you have any questions or require any additional assistance.

Sincerely,

Clayton L. Doke
Senior Petroleum Engineer



1) **Company Name & Address**

East Cherry Creek Valley Water and Sanitation District
6201 South Gun Club Road
Aurora, Colorado 80016

2) **Test Well Name & Location**

ECCV DI-1 Injection Well
SW/4 SW/4 Section 1 T1S R66W
Adams County, Colorado

3) **Facility Contact Person**

Clint Carter
Office: (720) 685-3367
Mobile: (303) 901-7681

Report Prepared by:

Clayton Doke
Integrated Petroleum Technologies, Inc.
1707 Cole Blvd, Suite 200
Golden, CO 80401
Office: (720) 420-5700

4) **Openhole Log**

See attached Triple Combo Log run 07/27/10

Injection Zones: Lyons, Wolfcamp, Amazon, Council Grove and Missouri formations

5) **Well Schematic**

See attached well schematic diagram

Wellbore radius:	0.365'
Completed interval depths:	Lyons: 9,152' – 9,253'
	Wolfcamp: 9,558' – 9,582'
	Amazon: 9,664' – 9,698'
	Council Grove: 9,702' – 9,706'
	Missouri: 10,002' – 10,038'
Type of completion:	Cased & cemented, injection under a packer set at 9,049' via 4-1/2" tubing

6) **Date of Fill Depth**

Current fill depth is 10,160', recorded on April 21, 2012, which is 122' below the bottom perforation.



7) Offset well information

The nearest well completed in the same formation is the Suckla Farms Injection Well #1, SENW Section 10-1N-67W, operated by KP Kauffman Company Inc. This well is completed in the Lyons formation and is approximately 9 miles to the north-west. No interference between these two wells is assumed to occur for the purposes of this analysis.

8) Chronological Listing of Daily Testing Activities

Injection averaged 6,643 bbls per day from 24th-Oct to 28th-Oct

10/24/16	Injection began at 276.78 BWPH Average
10/28/16	Injection stopped; 24,597.4 BW injected
11/06/16	Normal injection operations commence (total SI = 204.02 hrs)

9) Electronic Submission of Raw Data

The attached CD contains a file of raw time, rate, tubing pressure, annular pressure and wellhead temperature data prior to and during the falloff test.

10) Tabular Summary of Injection Rates

A hard copy of the tabular summary of the simplified rate data used in the analysis has not been included due to its length consisting of 5,864 rate changes. A plot of Rate, Tubing Pressure and Temperature vs Time has been included at the end of this report. The raw rate-time data is included in the .csv and .xlsx files on the attached CD. Due to its length, the .csv data has been divided between three separate files.

11) Offset Well Rate Information

As discussed above, no offset well rate information is considered to be useful in this test analysis.

12) Hard Copy of Time and Pressure Data

A hard copy of the tabular summary for the raw time, rate, pressure & temperature data from the testing period was not included in this report due to its length. A plot of Rate, Tubing Pressure, and Temperature vs Time has been included at the end of this report. The raw rate-time data is included in the .csv and .xlsx files on the attached CD. Due to its length, the .csv data has been divided between three separate files



13) Pressure Gauge and Flowmeter Information

Endress+Hauser Pressure Gauge:

Instrument: Cerabar S PMP71

SN: E904681509C

Installed at: Surface (Tubing)

Pressure accuracy: 0.075% of set span (+/- 4.50 psi)

Measurement range: 0 to 6,000 psi gauge

Calibration range: 0 to 2,992 psi gauge*

Last calibration check: July 21, 2016

*air in line prevented calibration to full 6,000 psi. All recorded pressures were within the calibrated range.

Endress+Hauser Pressure Gauge:

Instrument: Cerabar S PMP71

SN: F400031509C

Installed at: Surface (Annulus)

Pressure accuracy: 0.075% of set span (+/- 0.15 psi)

Measurement range: 0 to 200 psi gauge

Calibration range: 0 to 200 psi gauge

Last calibration check: July 21, 2016

Calibration certificates for both gauges are attached.

Below is the Endress+Hauser Recommended Calibration Interval for Pressure Devices:

- Directly mounted pressure measurement devices which operate with stable process conditions with the instrument located inside a building or plant (Normal conditions) should be calibrated every 4-6 years.
- If the same process conditions apply but the device is located outside then reduce the calibration interval to 1-4 years dependent on the extremes of the environment.
- If the device is fitted with a diaphragm seal then reduce the calibration period by a factor of two or alternately consider an interim inspection of the seal to verify its integrity.
- If the process pressure continually varies, or over pressure is a possibility then reduce the calibration period by a factor of two.

Based upon the last calibration date and the falloff test date, the gauges are within the manufacturer's recommended calibration interval.



Endress+Hauser Flowmeter:
Instrument: Promag 53W DN150
SN: EA06FA16000
Maximum measured error: +/-0.74%
Last calibration check: July 21, 2016

Calibration certificate for flowmeter is attached.

Below is the Endress+Hauser Recommended Calibration Interval for Electromagnetic Liquid Flowmeters:

- Assuming a homogenous process liquid at a stable temperature with the instrument working under normal ambient conditions then re-calibrate every 4-6 years.
- If the normal process conditions apply but the device is operating in hostile ambient conditions then reduce the calibration interval to 1-4 years dependent on the extremes of the environment.
- If the process fluid conditions are heavy (during cleaning in place for example) or the device is operated at the extremes of its temperature limits then re-calibration on an annual basis may need to be considered.
- If the process fluid is abrasive or corrosive then the calibration intervals should be reduced accordingly.
- The use of electronic verification tools, to check the sensor status and electronics performance can be applied on a 1- 2 year basis. If this is combined with maintenance and inspection routines then the calibration intervals suggested above can be extended by a factor of two.

Based upon the last calibration date and the falloff test date, the gauge is within the manufacturer's recommended calibration interval.

14) **General Test Information**

Falloff test injection commenced October 24, 2016 07:58 PM and ceased Oct 28, 2016 02:01 PM.
Surface pressure monitored from September 24, 2016 12:00 AM to November 06, 2016 02:02 PM.

Time synchronization: All data is from surface measurements and were recorded simultaneously. As such, no synchronization was necessary.

Location of shut-in valve: Well was shut in at the wellhead.



15) Reservoir Parameters

Water specific gravity (-):	1.007	(sample analysis by hydrometer)
Water viscosity (μ):	0.1947 cp	(correlation @ BHT)
Porosity (ϕ):	6%	(measured-density log porosity)
Total Compressibility (ct):	$6.726 \cdot 10^{-6} \text{ psi}^{-1}$	(correlation)
Formation Volume Factor:	1.069 rb/stb	(correlation)

Initial formation reservoir pressure: From the attached semi-log Diagnostic Analysis Radial plot, p^* is approximately 4,595 psia at the perforation midpoint.

A summary of historical estimates of Initial Formation Reservoir Pressure (p^*) at the perforation midpoint is as follows:

June 2013	3,795 psia
October 2014	4,308 psia
October 2015	4,422 psia
October 2016	4,595 psia

Date reservoir pressure was last stabilized: Reservoir pressure was stabilized prior to initial injection operations in May 2013, 42 months before the current falloff test.

Justified Interval Thickness: The total perforated completion interval of 199' was utilized as the interval thickness.

16) Waste Plume

Cumulative injection volume into completed interval: 9,510,673 bbls as of beginning of the falloff test Oct 28, 2016 at 02:01 PM. Initial injection operations began in May 2013.

Average historical waste fluid viscosity: some surface condition viscosities have been measured and comport well with correlation data. All of the waste fluid injected into the ECCV DI-1 has been reverse osmosis (RO) brine produced as a result of treating ground water, which does not have a significant contrast to the formation waters. Waste plume viscosity is assumed to be the same as formation fluid viscosity.

Calculated radial distance to the waste front: The waste volume injected through October 28th, 2016 is 9,510,673 bbls. Assuming piston displacement and no significant contrast in viscosity between the formation water and the waste water, the radius of the waste plume is approximately 1,234'.

Equation:

$$r_{inj} = \sqrt{\frac{5.615 \cdot V \cdot B_w}{\pi \cdot h \cdot \phi}} = \sqrt{\frac{5.615 \cdot 9,510,673 \cdot 1.069}{199 \cdot 0.06 \cdot \pi}} = 1,234'$$

where $V = 9,510,673$ bbls, $B_w = 1.069$ rb/stb, $h = 199'$, $\phi = 0.06$.

Note that no upper limit for injected waste volume was set for the ECCV DI-1 well.



17) Injection Period

Time: 07:58:00 PM 10/24/16 to 02:01:00 PM 10/28/16, 90.03 hours, 24,597.40 bbls

Type fluid: Reverse osmosis (RO) brine

Pump type: Water plant injection pump

Flowmeter: Endress+Hauser Promag 53W Electromagnetic Flowmeter

Final injection pressure @ surface:	1218.96 psi
Final injection pressure @ 9,595' mid-perf:	5,261.97 psia (calculated)
Final injection temperature @ surface:	50.82° F

18) Falloff Period

Total shut-in time: 02:01:00 PM 10/28/16 to 02:02:00 PM 11/06/16, 204.02 hours

Final shut-in pressure @ surface:	692.28 psi
Final shut-in pressure @ 9,595' mid-perf:	4,813.31 psia (calculated)
Final shut-in temperature @ surface:	51.48°F

19) Pressure Gradient

Since measurements were at surface, no static gradient was available for this test. Fluid level was at surface as evident from the positive pressure at the wellhead during the test.

21-22) Calculated Test Data and Corresponding Graphs

Please see attached graphs of the current test:

Data Chart	(Rate & Calculated Bottom Hole Pressure vs Time)
Diagnostic Analysis	(Log-Log Typecurve)
Diagnostic Analysis	(Radial Semi-Log Analysis)

The Rate, Tubing Pressure, Annular Pressure & Temperature vs Time plot shows surface injection pressure had essentially stabilized after the 90 hour injection period at ~1,218 psig. No pressure anomalies due to gauge temperature de-stabilization are evident during the test. Data quality appears good during the test.

The Diagnostic Analysis (Typecurve) shows that a short radial flow period was reached approximately 38 hours into the falloff portion of the test. Analysis of this region gives a system permeability of 5.02 md with a skin factor of -6.69.

Using the permeability value calculated from the falloff period, we can calculate a radius of investigation from the falloff test as follows for t = 204.02 hrs, with other parameters as defined above:

$$r_i = \sqrt{\frac{kt}{948\phi\mu c_i}} = \sqrt{\frac{5.15 \cdot 204.02}{948 \cdot .06 \cdot 0.1947 \cdot 6.726 \times 10^{-6}}} = 3,756'$$

Radius of investigation = 3,756'



Plots were generated using the Saphir software package available from Kappa Engineering, Paris, France. A .ks3 data file is included on the attached CD.

22) Comparison with Petition Demonstration

It is our opinion that the current test design is adequate to investigate this reservoir. We recommend that subsequent tests follow this same design.

23) Radioactive Tracer Survey

To date, no radioactive tracers have been run in this well.

24) Unusual Permit Approval Conditions

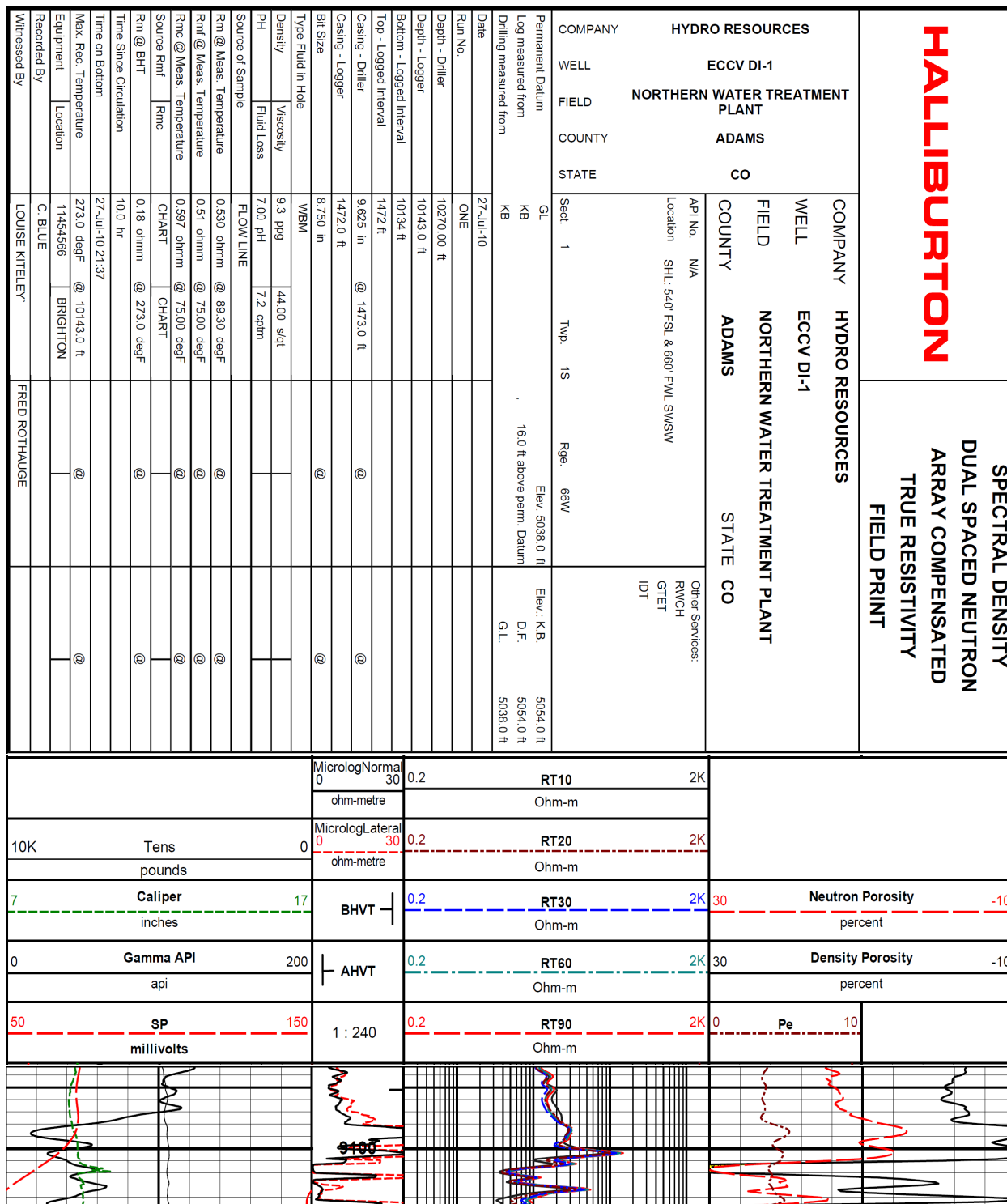
We are not aware of any unusual permit approval conditions.

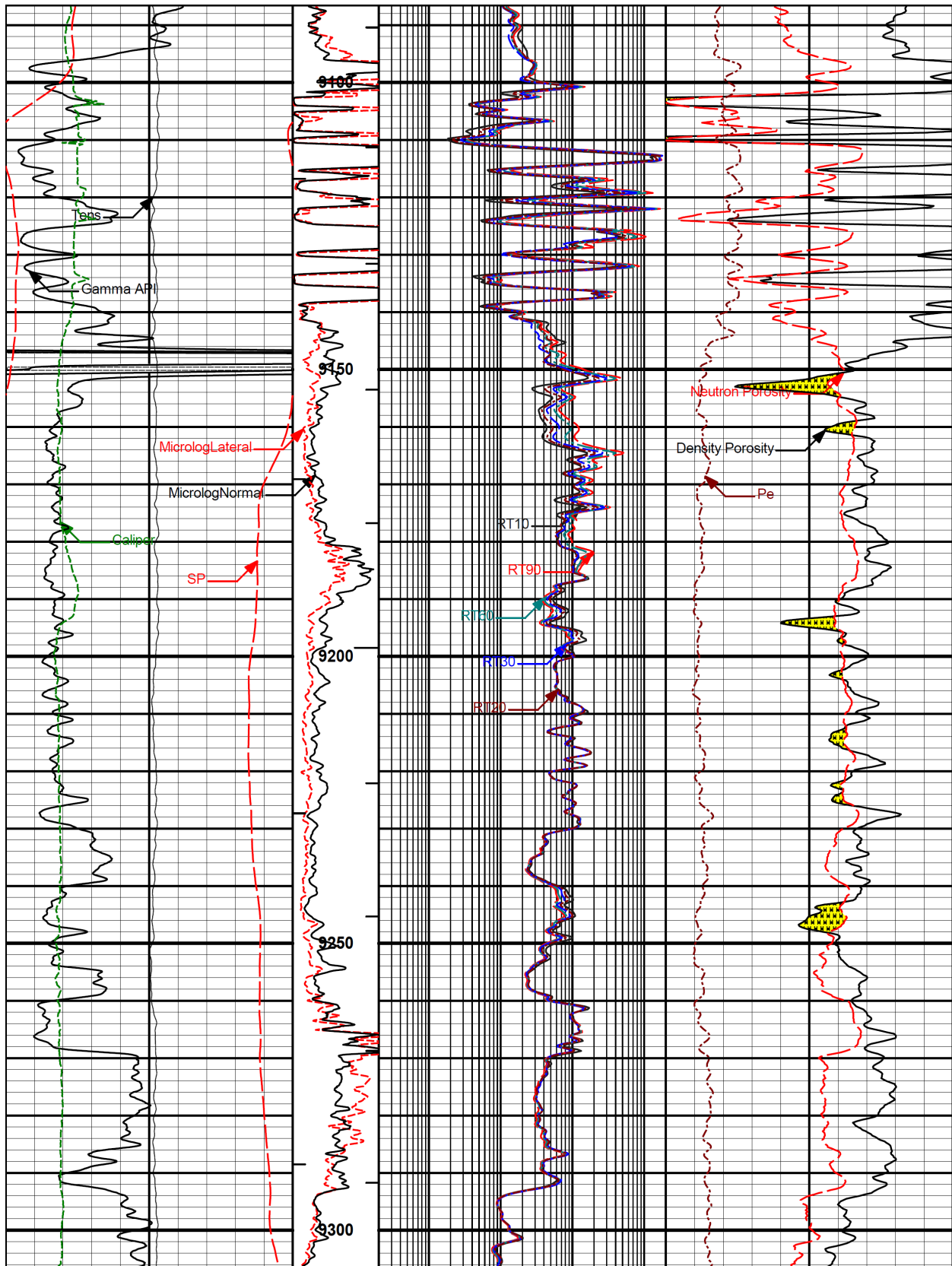
Report prepared for East Cherry Creek Valley Water and Sanitation District by

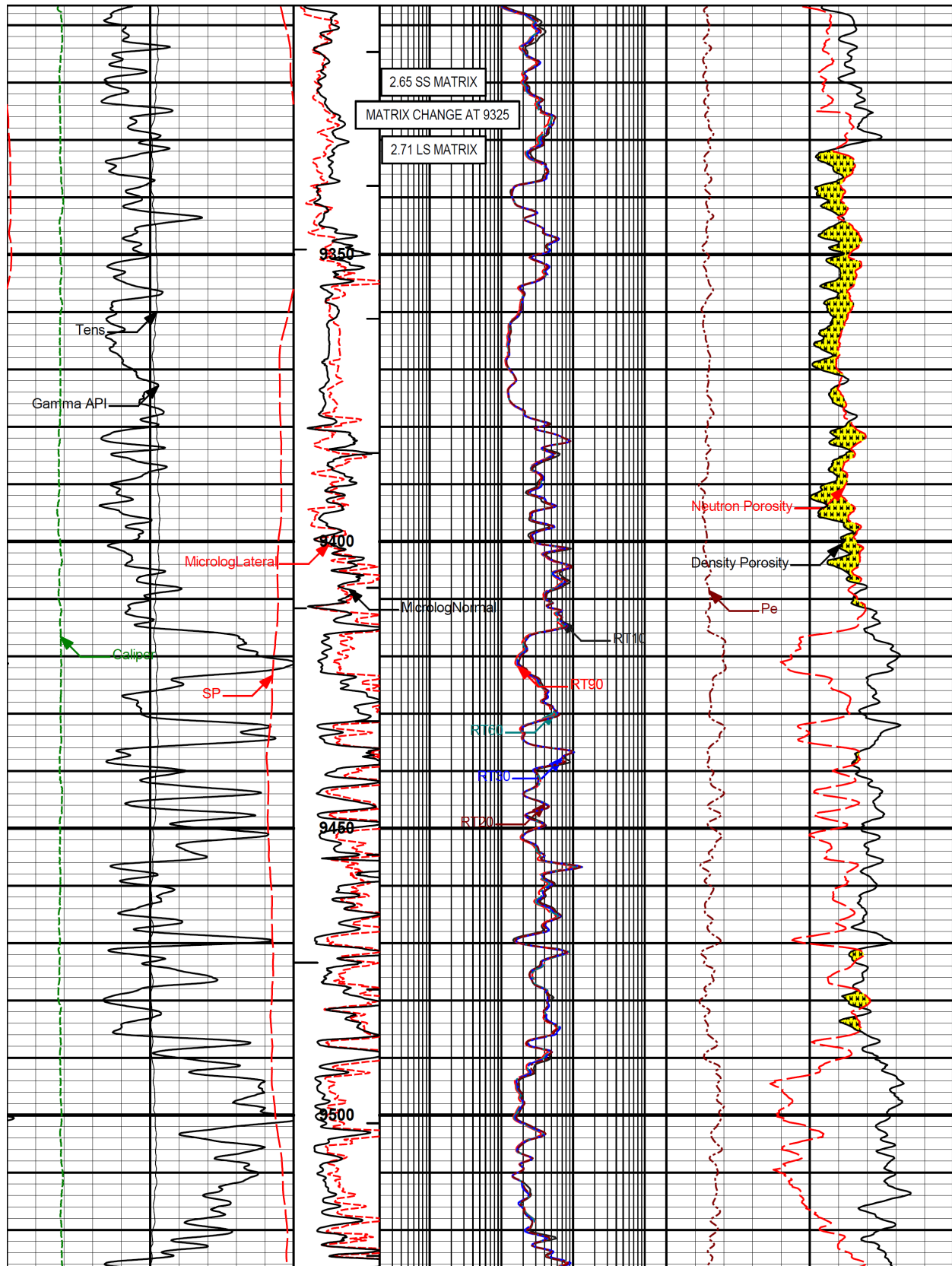
Integrated Petroleum Technologies, Inc.

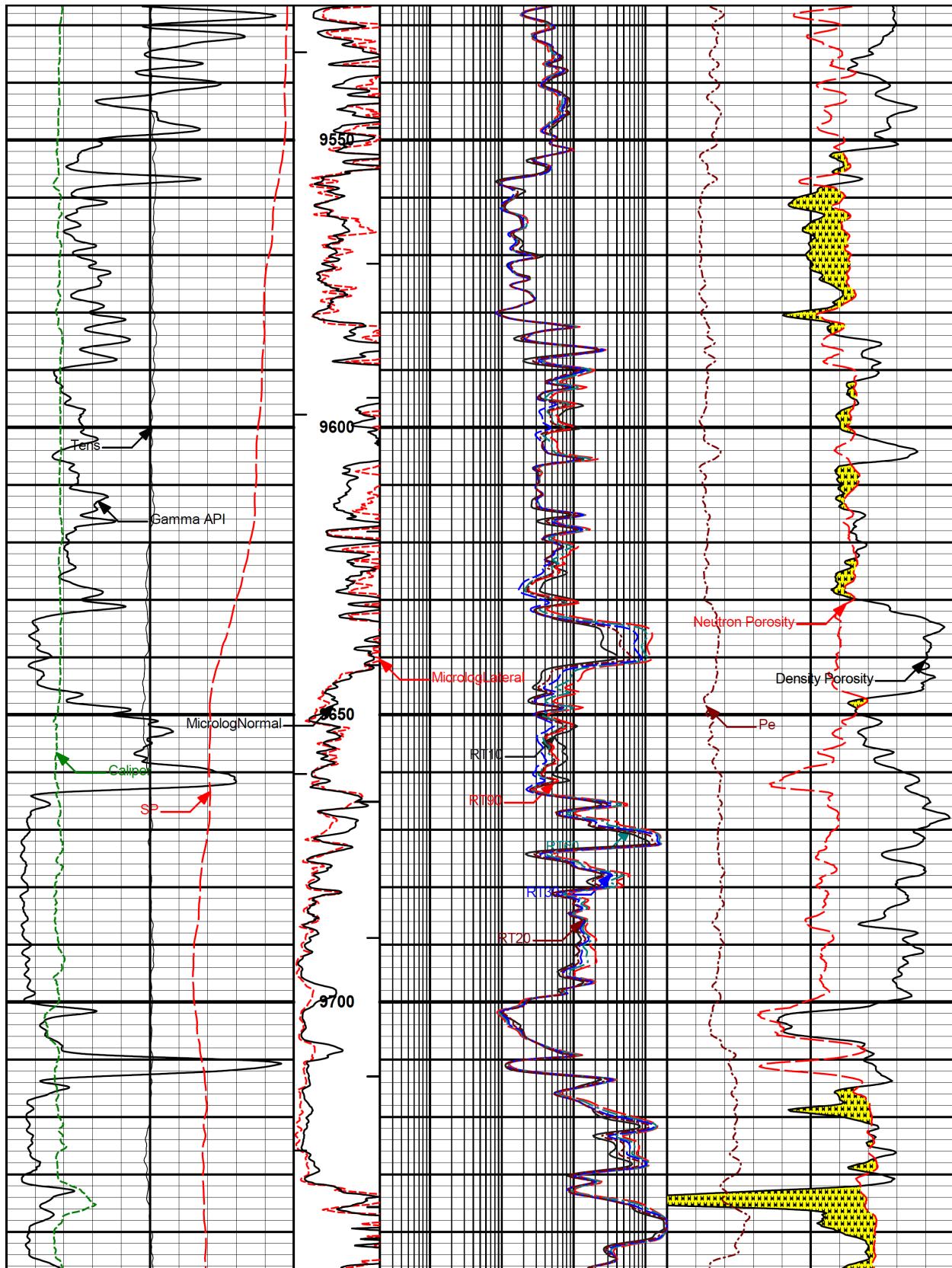
Clayton L. Doke
January 10, 2017

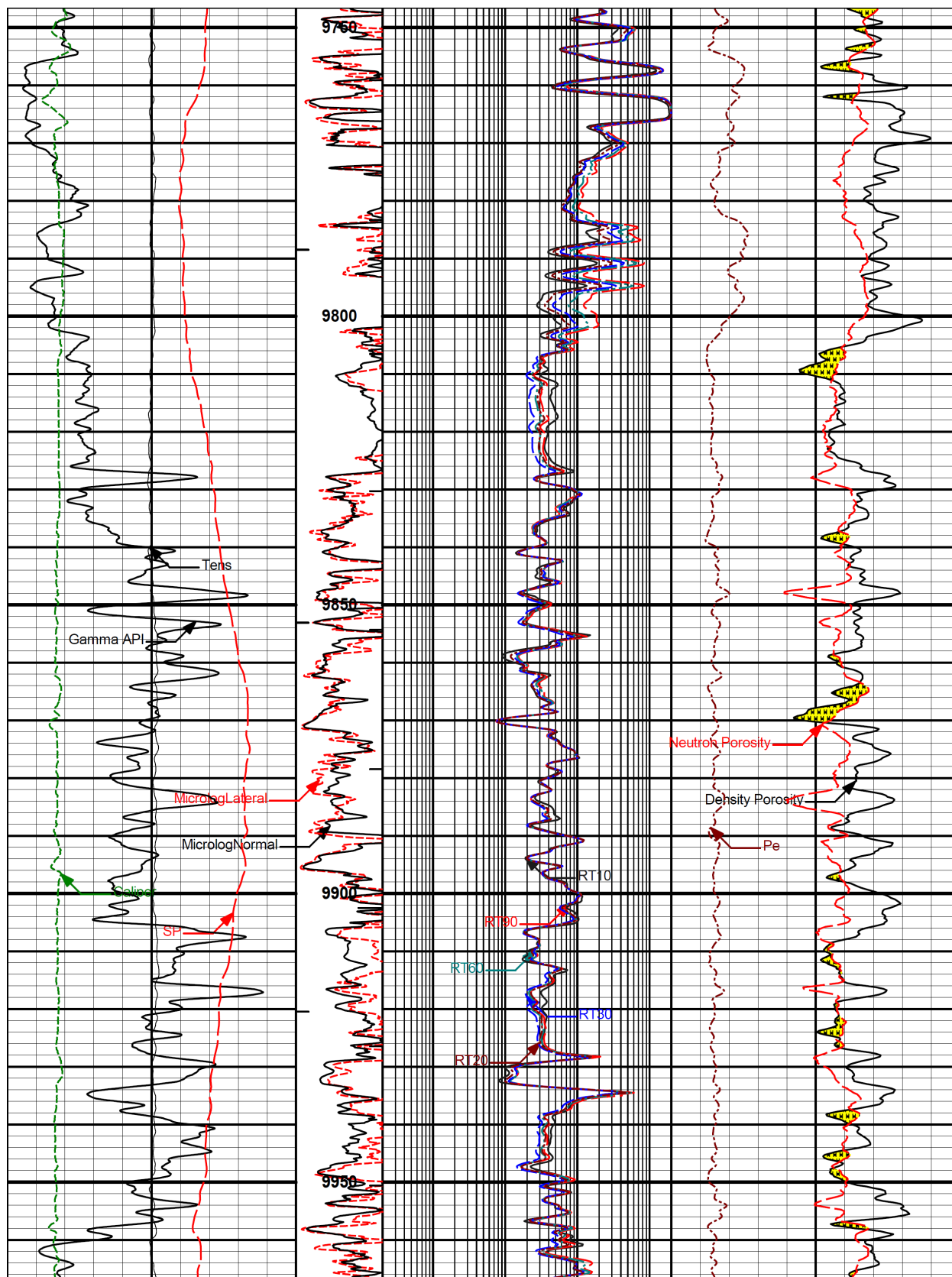
Reference: EPA Region VI UIC Pressure Falloff Testing Guideline, Third Revision, August 8, 2002

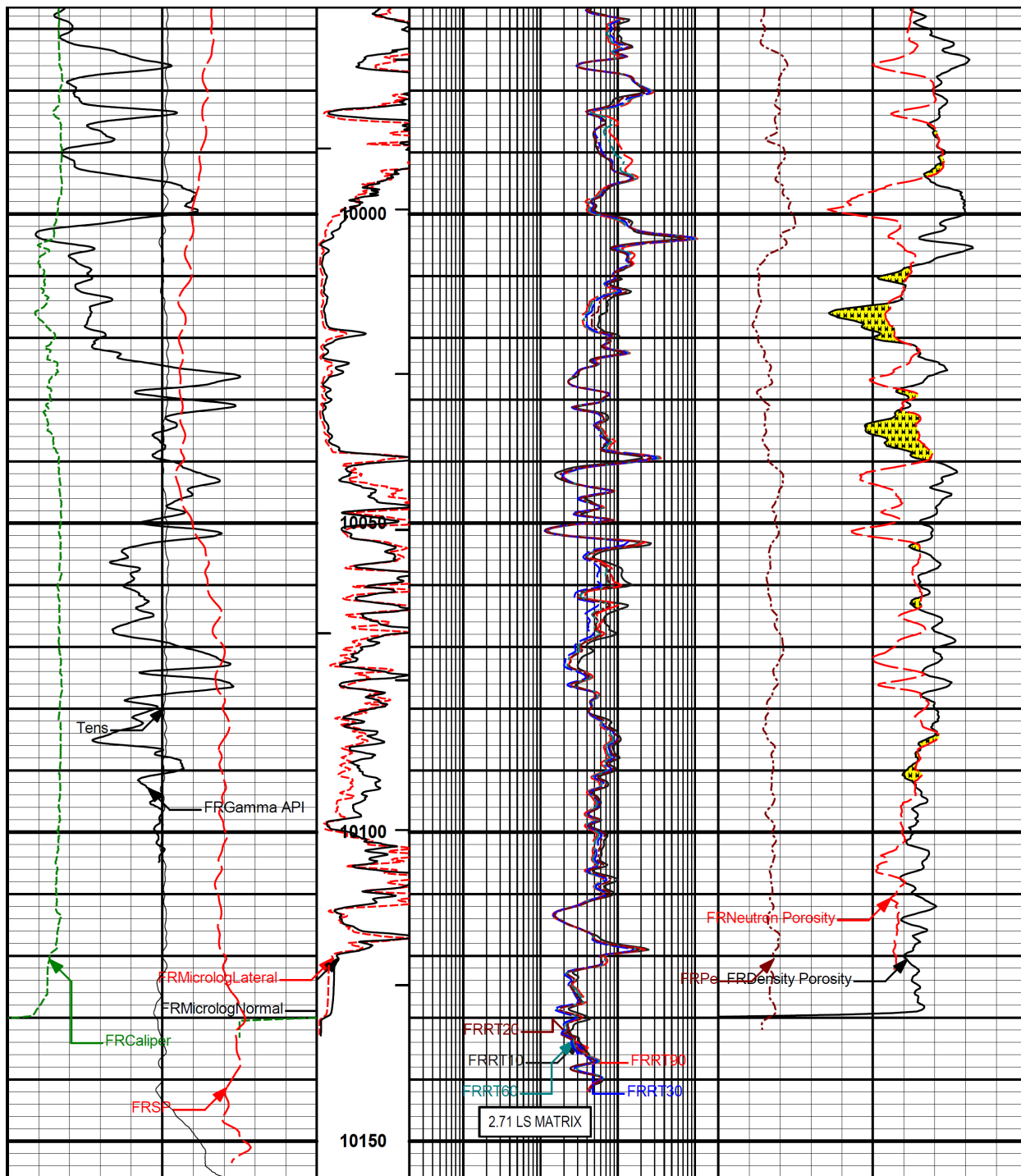














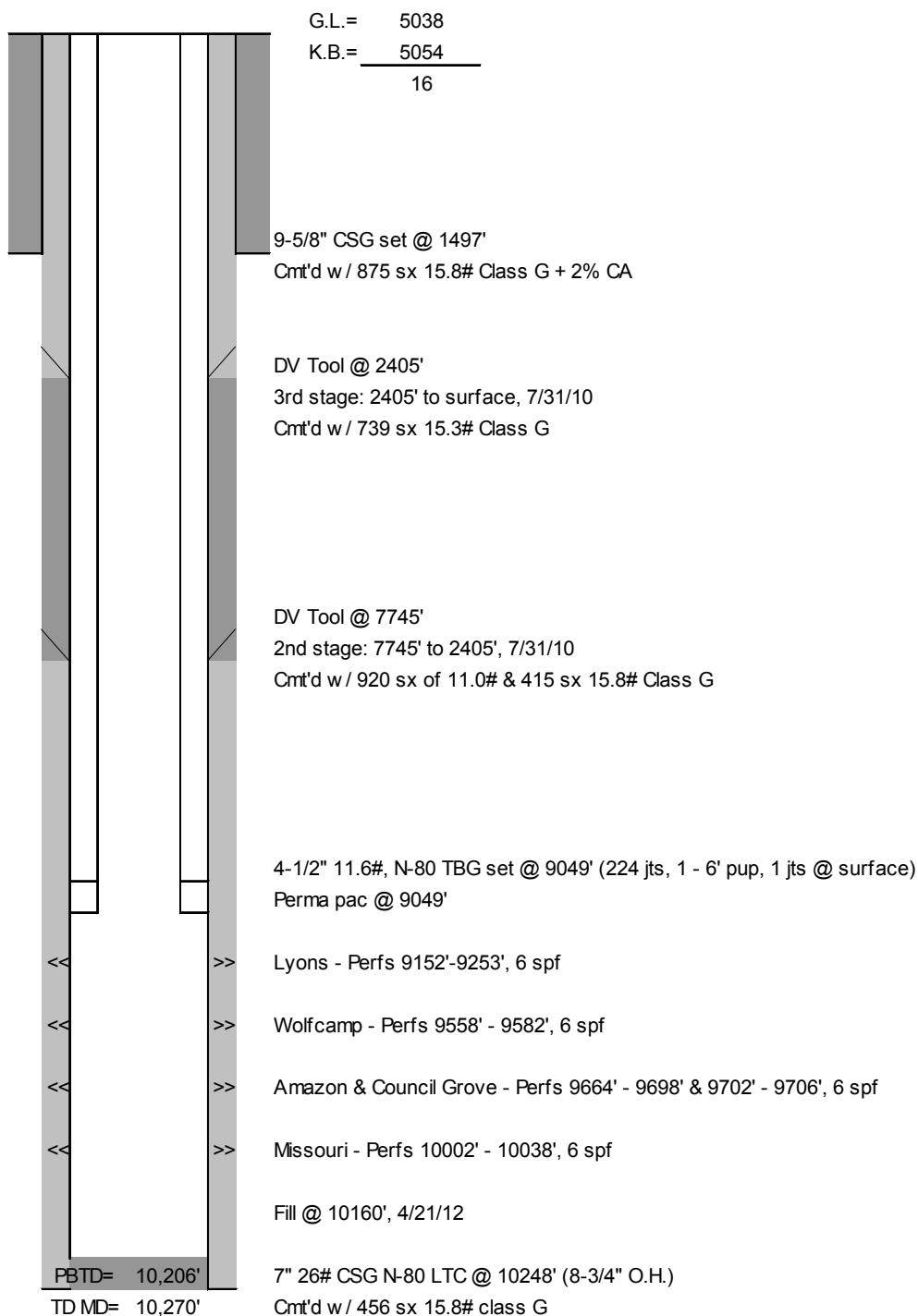
WELLBORE DIAGRAM

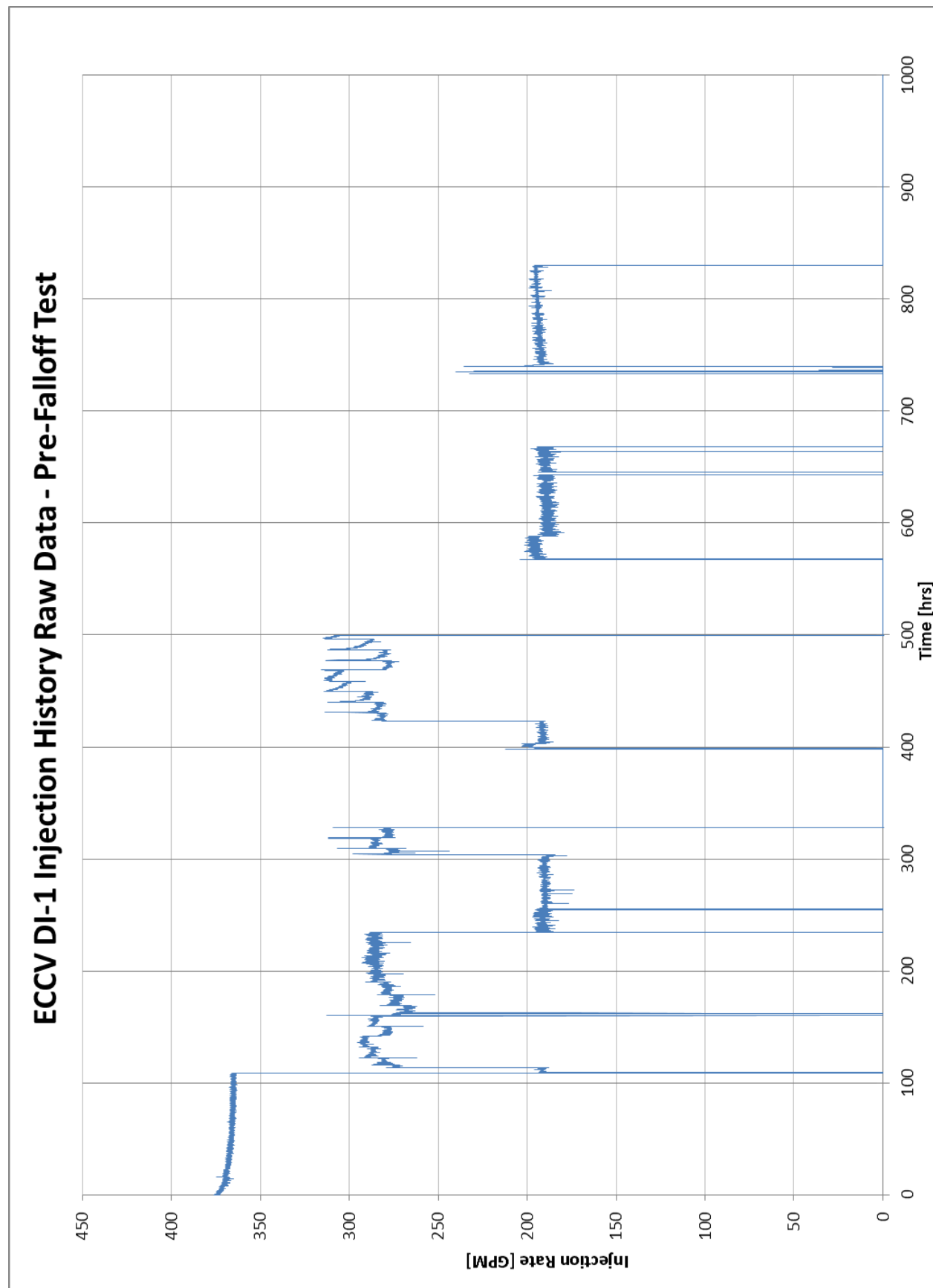
ECCV Water and Sanitation District

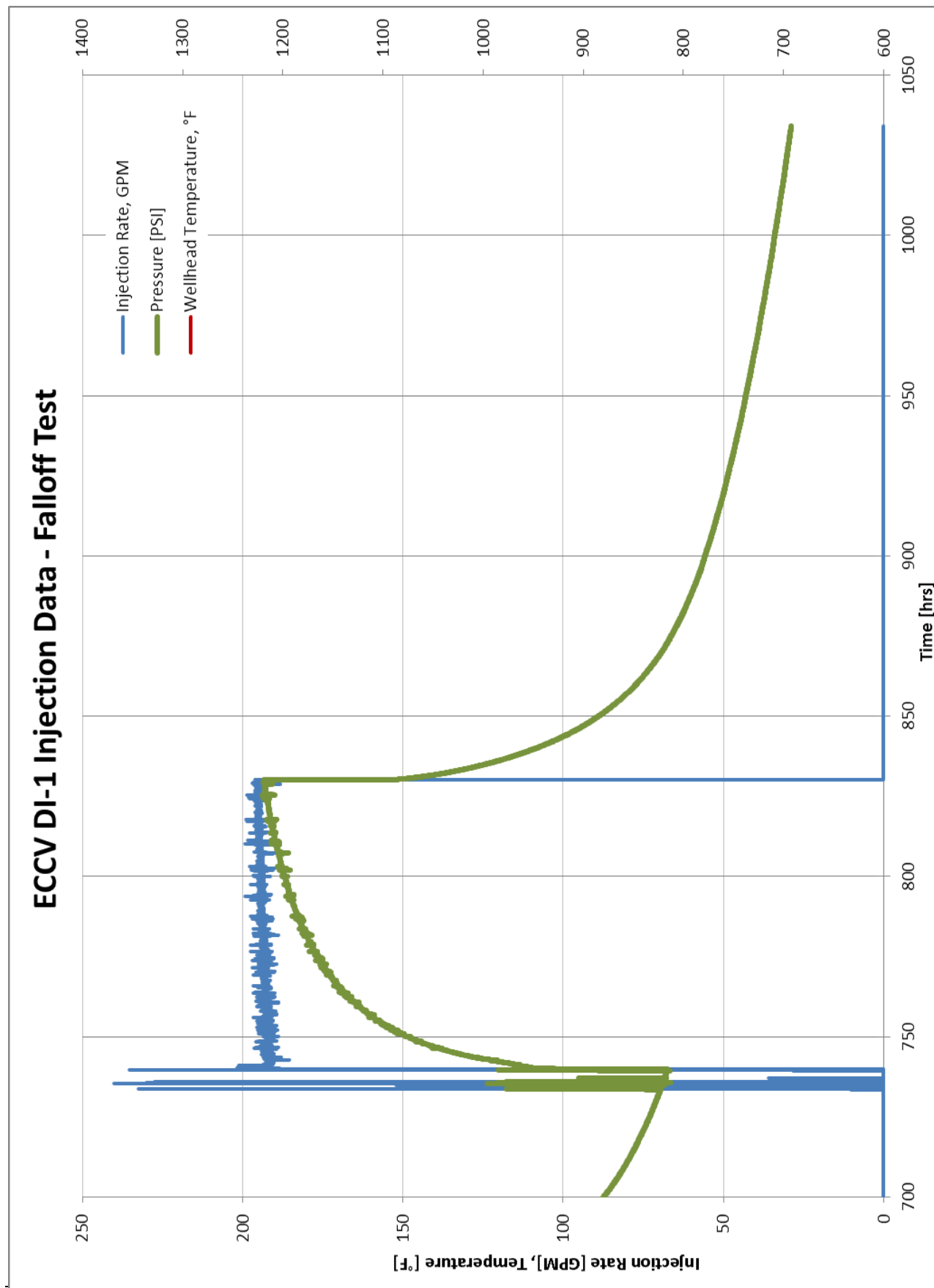
ECCV DI-1

SWSW 1-T1S-R66W
 SHL: 540' FSL, 660' FWL
 Adams County, Colorado
 EPA Class 1 Injection Well

Updated:
 7/18/2013
 SBP









Calibration Certificate Process Pressure

Endress+Hauser 

People for Process Automation

Certificate n° I7L1312SW
Calibration date 7/21/2016

Customer information

Company name East Cherry Creek Valley
Address 21850 I-76 Frontage Rd
Code City 80603 Brighton

Place of calibration

Company name East Cherry Creek Valley
Address 21850 I-76 Frontage Rd
Code City 80603 Brighton
Contact person Clint Carter

Instrument information (UUT)

UUT : Unit Under Test

Instrument (UUT) PMP71-SBC1W61RDANA
Serial n° E904681509C
Instrument Loc. Well house
Manufacturer Endress+Hauser
Tag n° PIT-27410

Measuring range 0 to 6000 psi gauge
Calibration range 0 to 2992 psi gauge
Max permissible error (MPE) 30.0 psi gauge

Standards used

Description	Serial n°	Certificate n°	Due date
Fluke 718 30G	1777077	10180015	7/8/2017
Fluke Pressure Module 700P30	90303004	1A21132KRV	10/2/2016

Calibration Method

SOP_C_en_PZ

Standard Operating Procedure for Calibration on site of pressure measurements

Environmental conditions

Ambient temperature 31 ± 3 °C

Calibration value As Found

Test Point	Reference Value	Display Value UUT	Output UUT	Deviation*	+/- MPE
	psi gauge	psi gauge	psi gauge	psi gauge	psi gauge
1.0	0.0	0.0	0.3	0.0	30.0
2.0	1496.0	1501.0	1499.0	5.0	30.0
3.0	2988.0	2992.0	2990.0	4.0	30.0

*(Maximum) Deviation to 'Reference value'

Calibration Point not conform

Conformity

☒ UUT conform

☐ UUT not conform

Next cal.

7/21/2017

Remarks

Measurement works within the specification

Unable to reach 6000psi due to air in the lines that could not be evacuated

This calibration certificate documents the traceability to national standards, which states the units of measurement according to the International System of Units (SI). This calibration certificate meets the requirements of the ISO/IEC 17025 standard. It should not be published or reproduced other than in full.



Service Technician Sam Walker
Signature

Printing date 7/21/2016



Calibration Certificate Process Pressure

Endress+Hauser 

People for Process Automation

Customer information

Company name **EAST CHERRY CREEK VALLEY WATER**
Address **6201 S GUN CLUB RD**
Code City **80016-2606 Aurora**

Certificate n° **I7L1312SW**
Calibration date **7/21/2016**

Place of calibration

Company name **EAST CHERRY CREEK VALLEY WATER**
(Location Info) **Brighton, CO**
Address **6201 S GUN CLUB RD**
Code City **80016-2606 Aurora**
Contact person **Mr. Clint Carter**

Instrument information (UUT)

UUT : Unit Under Test

Instrument (UUT) **PMP71-SBC1S61RAANA**
Serial n° **F400031509C**
Instrument Loc. **Deep Well Pump House**
Manufacturer **Endress+Hauser**
Tag n° **PTI-27415**
Bus-Address: **None**

Measuring range **0 to 200 psi gauge**

Calibration range **0 to 200 psi gauge**

Max permissible error (MPE) **1.0 psi gauge**

Standards used

Description	Serial n°	Certificate n°	Due date
Ftuke 718 30G	7148057	10180015	7/8/2017
Pressure Module 700P07	98200727	J6F0846KRV	6/15/2017

Calibration Method

SOP_C_en_PZ

Standard Operating Procedure for Calibration on site of pressure measurements

Environmental conditions

Ambient temperature **31 ± 3 °C**

Calibration value As Found

Test Point	Reference Value	Display Value UUT	Output UUT	Deviation*	+/- MPE
	psi	psi	psi	psi gauge	
1.0	0.0	0.0	0.1	0.1	1.0
2.0	100.0	100.2	100.1	0.2	1.0
3.0	200.0	199.8	199.9	0.2	1.0

*(Maximum) Deviation to 'Reference value'

Calibration Point not conform

Conformity

☒ UUT conform

☐ UUT not conform


Next cal.

7/21/2017

Remarks

Measurement works within the specification

This calibration certificate documents the traceability to national standards, which states the units of measurement according to the International System of Units (SI). This calibration certificate meets the requirements of the ISO/IEC 17025 standard. It should not be published or reproduced other than in full.


Service Technician **Sam Walker**
Signature

Printing date **7/21/2016**



DTM Version: 3.26.00

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Flowmeter Verification Certificate Transmitter

East Cherry Creek Valley Water

Customer

53W1F-ULGB1AC0BAAL

Order code

PROMAG 53 WDN150

Device type

EA06FA16000

Serial number

V2.03.00

Software Version Transmitter

07/21/2016

Verification date

Brighton WTP

Plant

FIT27400

Tag Name

1.0218 - 1.0218

K-Factor

1

Zero point

V1.05.03

Software Version I/O-Module

12:58 PM

Verification time

Verification result Transmitter: Passed

Test item	Result	Applied Limits
Amplifier	Passed	Basis: 0.55 %
Current Output 1	Passed	0.05 mA
Test Sensor	Passed	

FieldCheck Details

139525

Production number

1.07.06

Software Version

08/2015

Last Calibration Date

Simubox Details

8743937

Production number

1.00.01

Software Version

08/2015

Last Calibration Date

07/21/2016

Date

Sam Walker

Operator's Sign

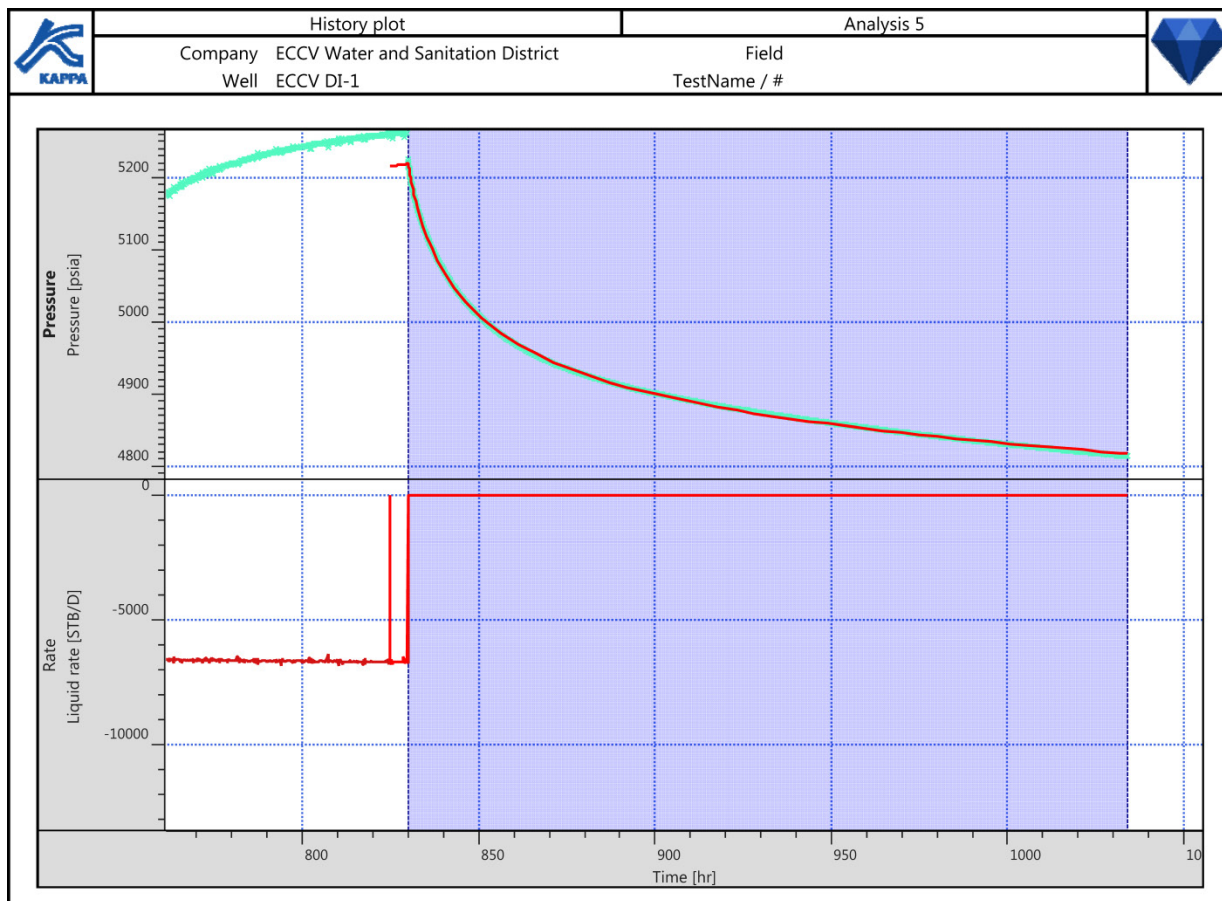
Inspector's Sign

Overall results:

The achieved test results show that the instrument is completely functional, and the measuring results lie within +/- 1% of the original calibration.¹⁾

The calibration of the Fieldcheck test system is fully traceable to national standards.

1) Prerequisite is an additional proof of electrode integrity with a high voltage test.

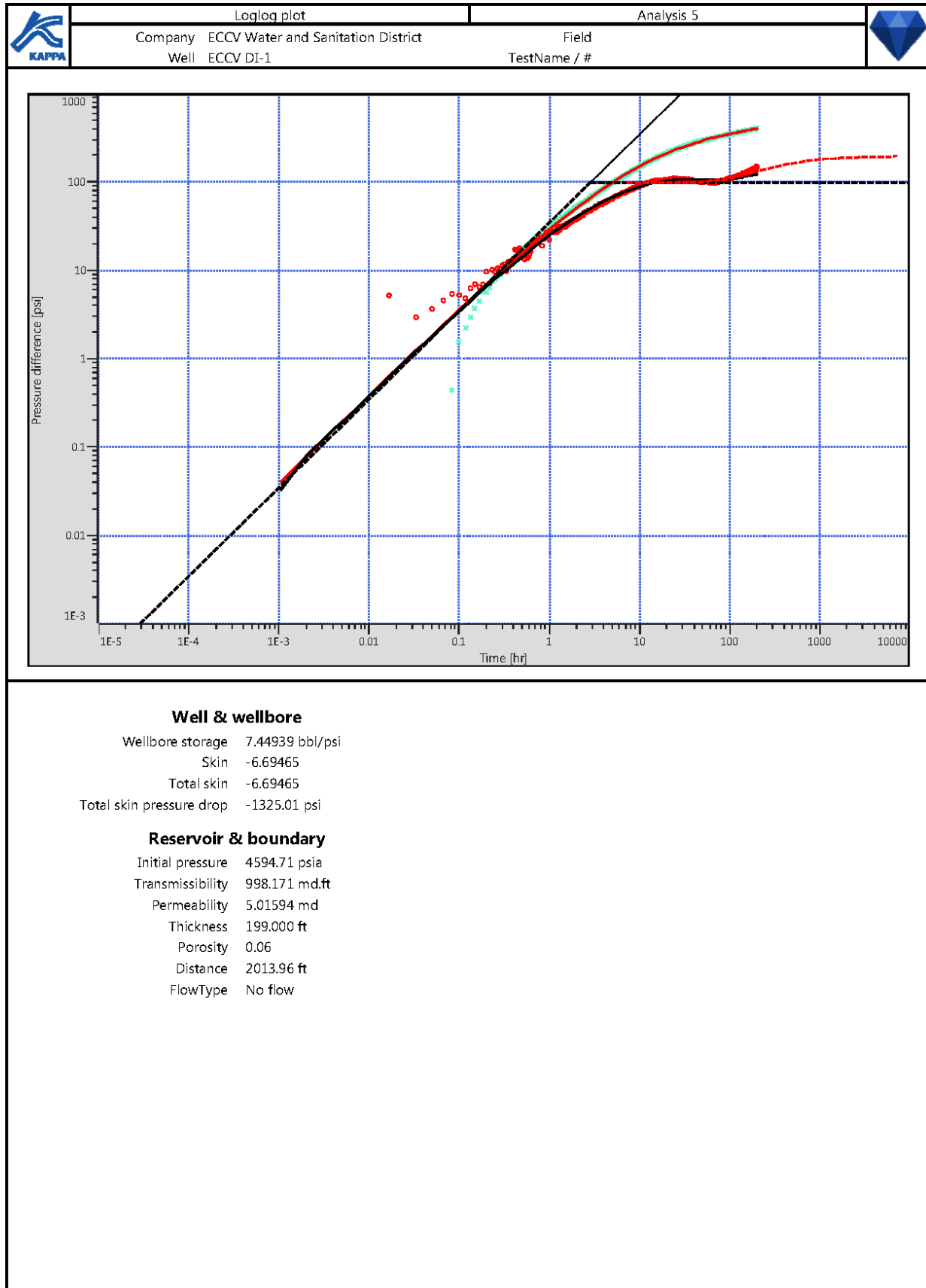


Well & wellbore

Wellbore storage 7.44939 bbl/psi
 Skin -6.69465
 Total skin -6.69465
 Total skin pressure drop -1325.01 psi

Reservoir & boundary

Initial pressure 4594.71 psia
 Transmissibility 998.171 md.ft
 Permeability 5.01594 md
 Thickness 199.000 ft
 Porosity 0.06
 Distance 2013.96 ft
 FlowType No flow



PTA

IPT\cdoke

1/11/2017 1:33 PM

1/1

